RECENT LITERATURE.

MILNE'S EARTHQUAKES[1].—This is a very timely work in view of the recent earthquake at Charleston. For this reason we shall for the use of our readers, abstract some of the leading points relating to earthquakes and their causes, which seem generally accepted and to accord with observed facts. While it is estimated that several earthquakes occur daily throughout the world, reference is also made to the smaller movements called "earth tremors," which occur so constantly that "it would appear that the ground on which we dwell is incessantly in a state of tremulous motion." A typical earthquake, however, consists of "a series of small tremors succeeded by a shock, or series of shocks, separated by more or less irregular vibrations of the ground." After discussing seismoscopes, instruments which are so constructed as to move at the time of an earthquake and leave a record of the motion, as well as seismographs, or record-receivers, earthquake motion is discussed theoretically, Mallet's and Abbot's results being given as well as the results obtained by the author in Japan.

A single shock is, as Mallet states, an impossibility. His statement is quoted as follows: "The almost universal succession of phenomena recorded in earthquakes is, first a trembling, then a severe shock, or several in quick succession, and then a trembling gradually but rapidly becoming insensible."

As the results of observations on the velocity of propagation of an earthquake it appears that in the Tokio earthquake of October 25, 1881, the disturbance must have traveled between Yokohama and Tokio at the rate of 4300 *feet per second*, but from Hakodate to Tokio at a velocity of 10,219 feet per second. Thus Milne concludes from his own observations and those on the Lisbon and other earthquakes, that:

1. Different earthquakes, although they may travel across the same country, have very variable velocities, varying between several hundreds and several thousands of feet per second.

2. The same earthquake travels more quickly across districts near to its origin than it does across districts which are far removed.

3. The greater the intensity of the shock the greater is the velocity.

Multiplied observations show that however chaotic at first sight appears the ruin produced by earthquakes there is in many cases "more or less law governing the positions of bodies which have fallen, the direction and positions of cracks in walls, and the various other phenomena which result from such destructive disturbances."

[1] *Earthquakes and other Earth Movements.* By JOHN MILNE, professor of mining and geology in the Imperial College of Engineering, Tokio, Japan. With thirty-eight figures. New York, D. Appleton & Co. 1886. 12mo., pp. 363.

Darwin tells us that in the earthquake at Concepcion, in 1835, the walls which ranged S. W. by W. and N. E. by E. stood better than those which ranged N. W. by N. and S. E. by S., the undulations coming from the S. W. In Caraccas, "the city of earthquakes," it is said that every house has its *laga securo*, or safe side, where the inhabitants place their fragile property. This *laga securo* is the north side, and it was chosen because about two out of every three destructive shocks traversed the city from west to east, so that the walls in these sides of a building have been stricken broadside on."

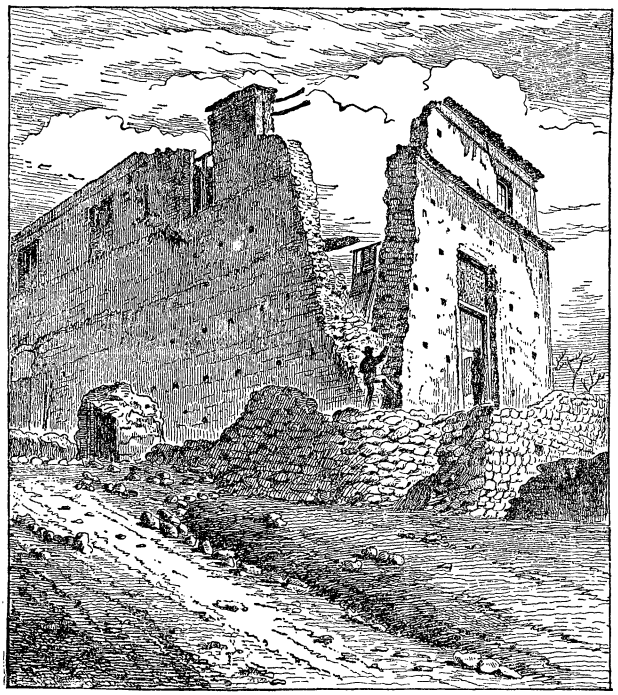

FIG. 1.—The Cathedral at Paterno, struck obliquely by the Neopolitan earthquake of 1857.

Special districts also, in an earthquake country, are free from shocks, since Milne tells us that even in a country like Japan, where there are on the average at least two earthquakes per day, it is possible to choose a place to build in as free from earthquakes as Great Britain. Caverns, wells, quarries, moats and the proximity to ravines and cañons protect a small region from the severe shocks of earthquakes.

Seismic disturbances in the ocean are discussed in the ninth chapter. Among the most striking examples is that of Iquique,

Peru. The sea-wave of the Iquique earthquake of May 9, 1877, like many of its predecessors, was felt across the basin of the whole Pacific, from New Zealand in the south to Japan and Kamschatka in the north, and but for the intervention of the Eurasian and American continents would have made itself appreciable over the whole of our globe. At places on the South American coast it has been stated that the height of the waves varied from twenty to eighty feet. At the Samoa islands the heights varied from six to twelve feet. In New Zealand the sea rose and fell from three to twenty feet. In Australia the heights to which the water oscillated were similar to those observed in New Zealand. In Japan it rose and fell from five to ten feet. In this latter country the phenomena of sea-waves which follow a destructive earthquake on the South American coast are so well known that old residents have written to the papers announcing the probability of such occurrences having taken place some twenty-five hours previously in South America. In this way news of great calamities has been anticipated, details of which only arrived some weeks subsequently. Just as the destructive earthquakes of South America have announced themselves, in Japan; in a like manner, the destructive earthquakes of Japan have announced themselves upon the tide gauges of California.

Similarly, but not so frequently, disturbances shake the other oceans of the world. For example, the great earthquake of Lisbon propagated waves to the coasts of America, taking on their journey nine and a half hours.

The complete set of phenomena which may accompany a violent sub-marine explosion is as follows (p. 174):

By the initial impulse of explosion or lifting of the ground, a "great sea-wave" is generated, which travels shorewards with a velocity dependent upon its size and the depth of the ocean; at the same instant a "sound-wave" may be produced in the air, which travels at a quicker rate than the "great sea-wave." A third wave which is produced is an "earth-wave," which will reach the shore with a velocity dependent on the intensity of the impulse and the elasticity of the rocks through which it is propagated. This latter, which travels the fastest, may carry on its back a small "forced sea-wave." On reaching the shore and passing inland, this "earth-wave" will cause a slight recession of the water as the "forced sea-wave" slips from its back.

As these "forced sea-waves" travel they will give blows to ships beneath which they may pass, being transmitted from the bottom of the ocean to the bottom of the ships like sound-waves in water. At the time of small earthquakes, produced, for example, by the explosions of small quantities of water entering volcanic fissures, or by the sudden condensation of steam from such a fissure entering the ocean, aqueous sound-waves are produced

which cause the rattling and vibrating jars so often noticed on board ships.

But out of 15,000 earthquakes observed on coast lines, only 124 were accompanied by sea-waves. Out of 1098 recorded on the west coast of South America only nineteen are said to have been accompanied by sea-waves; but from additional facts stated, almost every severe earthquake on that coast has been accompanied by considerable agitation in the neighboring sea.

"On April 2, 1851, when many towns in Chili were destroyed, the sea was not disturbed. At the time of the great earthquake of New Zealand (June 23, 1855), although all the shocks came from the sea, yet there was no flood. The small shock of February 14, however, was accompanied by a motion in the sea." To these facts, taken from Fuchs' work, our author adds the fact that the

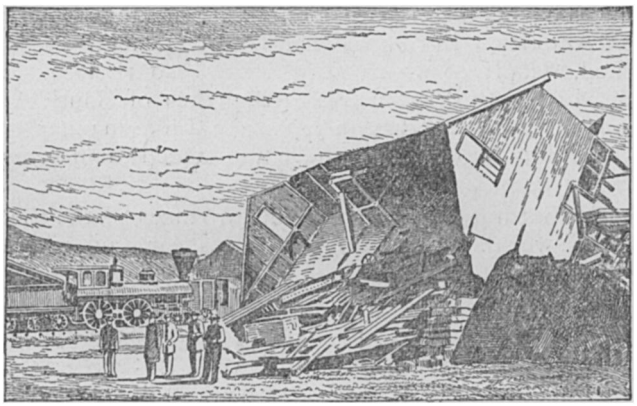

FIG. 2.—Stud mill at Haywards, California, swung completely over.

greater number of disturbances which are felt in the northeastern part of Japan, although they emanate from beneath the sea, do not produce any visible sea-waves. They are, however, sufficient to cause a vibratory motion on board ships situated near their origin.

It has been long known by physicists that the velocity with which a given wave is propagated along a trough of uniform depth, holds a relation to the depth of the trough; hence calculations of the average depths of the Pacific, dependent on the velocity with which earthquake waves have been propagated, have been made by many investigators, but Milne thinks these are open to criticisms in consequence of the writer having assumed that the wave originated on a coast line, when the evidence clearly showed that it originated some distance out at sea. As an example of such calculations we copy Milne's account of the wave of 1868:

"On August 11, 1868, a sea-wave ruined many cities on the

South American coast, and 25,000 lives were lost. This wave, like all the others, traveled the length and breadth of the Pacific.

"In Japan, at Hokodate, it was observed by Captain T. B. Blakiston, R. A., who very kindly gave me the following account:

"On August 15, at 10.30 A.M., a series of bores or tidal-waves commenced, and lasted until 3 P.M. In ten minutes there was a difference in the sea level of ten feet, the water rising above high-water and falling below low-water mark with great rapidity. The ordinary tide is only two and a half to three feet. The disturb-

FIG. 3.—Church of St. Augustine, Manilla. Earthquakes of July 18–20. 1880.

ance producing these waves originated between Iquique and Arica, in about lat. 18°28′ S. at about 5 P.M., on August 13. In Greenwich time this would be about 13 h. 9 m. 40 s., August 13. The arrival of the wave at Hakodate in Greenwich time would be about 14 h. 7 m. 6 s., August 14; that is to say, the wave took about 24 h. 57 m. to travel about 8700 miles, which gives us an average rate of about 511 feet per second. These waves were felt all over the Pacific. At the Chatham islands they rushed in with

such violence that whole settlements were destroyed. At the Sandwich islands the sea oscillated at intervals of ten minutes for three days."

Comparing this wave with the one of 1877 we see that one reached Hakodate with a velocity of 511 feet per second, whilst the other traveled the same distance at 512 feet per second.

Other practical problems are the determination of earthquake origins and the depth of an earthquake centrum, discussed in Chapters X and XI. From Mallet's calculations the greatest possible depth of any earthquake shock is limited to about thirty geographical miles, but Milne adds that the origin of the Owen's Valley earthquake of March, 1872, was estimated (Amer. Jour. Sc., 1872) as being at least fifty miles below the surface.

Under the head of distribution of earthquakes in space and time, reference is made to a map which does not appear in our

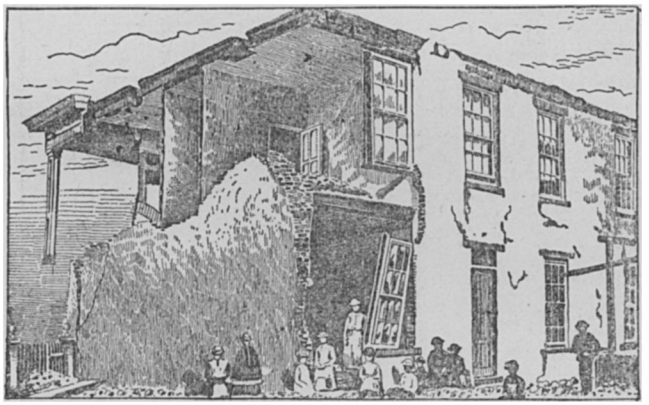

FIG. 4.—Webber House, San Francisco, Oct. 21, 1868, showing the effect produced on an end building.

copy of the book. As an example of the vast area over which an earthquake is sensible, that of Lisbon in 1755 is given, which was felt over an area of 3300 miles long and 2700 miles wide, "but in the form of tremors and pulsations it may have shaken the whole globe." Earthquakes chiefly occur in volcanic and mountainous regions. "Looking at the broad features of the globe, we see on its surface many vast depressions. Some of these saucer-like hollows form land surfaces, as in Central Asia. The majority of these, however, are occupied by the oceans. Active volcanoes chiefly occur near the rim of the hollows which have the steepest slopes. The majority of earthquakes probably have their origin on or near the bottom of these slopes."

As to the frequency of earthquakes Kluge's estimate of 4620 between the years 1850 and 1857, averaging nearly two a day, is

thought by our author to be much below the truth, as there may be perhaps ten and perhaps one hundred, it being impossible to state the number definitely.

Milne concludes, after a lengthy discussion of the facts, that the majority of earthquakes are due to explosive efforts at volcanic foci. "The greater number of these explosions take place beneath the sea, and are probably due to the admission of water through fissures to the heated rocks beneath. A small number of earthquakes originate at actual volcanoes. Some earthquakes are produced by the sudden fracture of rocky strata or the production of faults. This may be attributable to stresses brought about by elevatory pressure. Lastly we have earthquakes due to the collapse of underground excavations."

The work concludes with brief chapters on earth tremors, earth pulsations and earth oscillations.

WHEELER'S REPORT UPON THE THIRD INTERNATIONAL GEOGRAPHICAL CONGRESS.—"Better late than never" is the adage which enters the mind upon reading that the congress, the proceedings of which are here reported, was held at Venice, Italy, during the last half of the calendar year 1881. As these geographical congresses are held every five years, this volume just escapes being mistaken for a forecast of the fourth congress. Representatives from twenty-nine nationalities, embracing three-fourths of the earth's inhabitants, were present. The question of a common initial meridian and uniform standard time seems to have been the most prominent matter brought before the attention of the assembled geographers and explorers, but votes were taken upon forty-seven questions. Among these were the exact trigonometrical determination of the position of light-houses, the establishment of subordinate meteorological stations to connect polar stations with those in middle latitudes; the desirability of registering the superficial temperature of the soil; the compilation of a universal phonetic alphabet; the representation of mountains (in elementary atlases) by level curves; the fixation of a universal scheme of coloration for different heights, depths, and kinds of soil, and the preparation of lists of the explorers of each country. The Exhibition was held in seventy-four rooms in the royal palace, and was attended by about 150,000 visitors.

The principal part of the volume is occupied with an account of the Government Land and Marine Surveys of the World, commencing with a summary of the origin, organization, administration, functions, history, and progress of these surveys, with lists of the general and special topographic maps published, etc. Capt. Wheeler states that in all the older civilized countries the topographic survey is the principal one, and that in all large and well organized Governments it has been continuously maintained under military administration. No such survey now exists in the United